EVALUATION OF AN AUDIO-TUTORIAL METHOD OF TEACHING BIOCONCEPTS AT SOUTHWESTERN OKLAHOMA STATE UNIVERSITY

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The college population of the 1970's has far surpassed the predictions made by demographers and sociologists (Clark, 1960). Original estimates ranged from 6.5 million to 7.5 million college students by the mid 1970's. At the present time, however, the number of persons enrolled in postsecondary education courses of one kind or another exceeds 8.5 million (O'Grady, 1971).

The major increase in college enrollment has been among adults (Jones, 1974). Most of these students have enrolled as a means of furthering their education, obtaining a second skill, or updating their present education. Most have had some previous postsecondary education. This has resulted in a wide range of abilities and proficiency levels among the students within a given class. Most instructors have attempted to make some allowances for such differences, but one alternative seems to be a system of individualized instruction or self-teaching materials.

Some attempts have been made to use programmed teaching materials. Collett (1975) used linear programmed teaching materials to teach spelling to 215 Viet Nam War Veterans in a Special Reading Class at Oscar Rose Junior College in Midwest City, Oklahoma. She found that the veterans who were

taught spelling by the self-teaching auditory method were much more proficient than a second group of veterans who were taught spelling by a conventional method.

In a comparable study for junior high school students, Ellis (1976) compared math achievement scores of 585 junior high school students who had been taught math through the Individually Prescribed Instruction (IPI) technique with math achievement scores of 1,040 junior high students who had been taught math by a traditional method. The results indicated that there was not a significant difference between the two groups' math achievement scores. Ellis concluded that the IPI method of teaching math was advantageous only insofar as it allowed for individual student differences.

In another study comparable to the present research effort, Meyers (1970) compared the pretest-posttest achievement gains of students who had been taught science concepts by the audio-tutorial method with the pretest-posttest achievement gains of students who had been taught science concepts by a traditional lecture method. Meyers reported that students in the audio-tutorial group made significantly greater achievement gains than students in the traditional group.

The results presented in these three studies indicate that there is still some question as to whether self-programmed, individualized-instruction techniques are beneficial to students' achievement.

The purpose of the present study was to evaluate the

audio-tutorial method of teaching bioconcepts in regard to the academic achievements and attitudes of students enrolled in a bioconcepts course at Southwestern Oklahoma State University during the fall semester of the 1976-77 academic year. Primary comparisons were made between the science majors' achievement and attitude and the non-science majors' achievement and attitude. Results of the study may be used to help determine the appropriateness of the audio-tutorial method of teaching the bioconcepts course at Southwestern Oklahoma State University.

The primary questions which were addressed in the study were as follows: Do college students achieve well if they are taught bioconcepts with an audio-tutorial (A. T.) method than without the method? If so, is the A. T. method more applicable for science majors than non-science majors? How does the use of the A. T. method in teaching bioconcepts change the students' attitudes toward the course and course content? If attitude changes occur, are they different for science majors and non-science majors?

Statement of the Problem

The purpose of this study was to determine possible effects of an audio-tutorial method of teaching on the achievement and attitude of students. More precisely, the purpose of the study was to determine the effects of an audio-tutorial method of teaching bioconcepts on the academic achievement and attitudes of students enrolled in a

bioconcepts course at Southwestern Oklahoma State University during the fall semester of the 1976-77 academic year. Primary comparisons were made between the attitudes and achievement scores of science and non-science majors, physical science and biological science majors, males and females, and upper classmen and lower classmen.

Hypotheses

The following null hypotheses were tested for significance at the .05 level.

Ho_1 There is no significant difference between the students' achievement at the beginning of the bioconcepts course and at the end of the course.

Ho_2 There is no significant difference between the students' attitudes at the beginning of the bioconcepts course and at the end of the course.

Ho_3 There is no significant difference between the science majors' achievement change scores and the non-science majors' achievement change scores.

Ho_4 There is no significant difference between the science majors' attitude change scores and the non-science majors' attitude change scores.

Ho_5 There is no significant difference between the physical science majors' achievement change scores and the biological science majors' achievement change scores.

Ho_6 There is no significant difference between the physical science majors' attitude change scores and the biological science majors' attitude change scores.

Ho_7 There is no significant difference between the males' achievement change scores and

the females' achievement change scores.

Ho_8 There is no significant difference between the males' attitude change scores and the females' attitude change scores.

Ho_9 There is no significant difference between the upper classmens' achievement change scores and the lower classmens' achievement change scores.

Ho_{10} There is no significant difference between the upper classmens' attitude change scores and the lower classmens' attitude change scores.

Definitions of Terms

Several terms were used in the course of the investigation which require a definition. These definitions are presented in this section of the proposal. It should be noted, however, that the explanations offered are not an attempt to formulate universal definitions, but are simply an elaboration of the manner in which the terms were used in the present study.

Students/College Students: Persons who were enrolled in the Introductory bioconcepts course (Biology 1004) at Southwestern Oklahoma (Weatherford, Oklahoma) during the fall semester of the 1976-77 academic year.

Bioconcepts: The content material taught in the introductory science course at Southwestern Oklahoma State University. This course is primarily a combination of biology and botany concepts. A further explanation of the course context is presented in Chapter III.

Non-Science Majors: Students whose major field of

concentrated study at Southwestern Oklahoma State University is not in one of the pure or applied sciences.

Audio-Tutorial Method of Teaching: The method of teaching utilized by the instructors who taught the various sections of Biology 1004 at Southwestern Oklahoma State University. This method consisted primarily of supervised learning centers equipped with auditory and visual aids which allowed students to begin at their own level of competency and proceed at their own pace.

Science Majors: Students whose major field of concentrated study at Southwestern Oklahoma State University is in one of the pure or applied sciences such as Botany, Zoology, Chemistry, Physics, and Geology.

Achievement Score: The students' scores taken from the criterion-referenced testing instruments designed to measure the acquisition of knowledge in the audio-tutorial bio-concepts course.

Attitude Scores: The students' scores taken from the Semantic Differential testing instrument presented in the Appendices.

Physical Science Majors: Students who participated in the study who have a declared major field of study in either Chemistry, Geology, or Physics.

Biological Science Majors: Students who participated in the study who have a declared major field of study in either Botany, Zoology, Micro-biology, Physiology, or Genetics.

Upper Classmen: Junior and Senior students who participated in the study.

Lower Classmen: Freshman and Sophomore students who participated in the study.

Rationale

Many new methods of instruction are being used in colleges and universities throughout the United States. These methods of instruction are replacing conventional methods of instruction. One of the more promising techniques of new instruction is known as the Audio-Tutorial (A. T.) technique. This method can be easily adapted to almost any curriculum and it allows students to begin at their particular level of competency and progress at their own rate of speed.

In 1961, Postlehwait implemented an audio-tutorial method of teaching Botany to Purdue University freshmen. He reported outstanding results of the program and recommended that it be implemented by other colleges and universities.

Perhaps one of the more outstanding virtues of the A.T. method of teaching is that it allows the individuality of the students. Not only do the students have some choice of teaching techniques--listening, seeing, or doing--and a choice of pacing, but they know in advance what they should learn any particular A. T. experience. An additional advantage of the A. T. system is that it gives the instructor more

freedom and flexibility to interact personally with each student.

This study was an attempt to evaluate selected dimensions of an audio-tutorial (A. T.) method of teaching General Biology in a small mid-western university. Participants were science and non-science majors from all four grade classifications.

Results of the study could be beneficial in several ways, including those which follow. First, the results could give some indication of the A. T. program's appropriateness for non-science majors. Most college science programs are designed by scientists for scientists. The results of this study could determine how appropriate this A. T. program is for non-science majors. Second, the results of the study could be used to determine the effects of the A. T. program on the attitude of the students participants. Third, the results could yield information concerning the course content, presentation, format, concepts taught, etc. Further, the results could indicate any differences between the science and non-science majors' attitudes toward the A. T. method of teaching General Biology at the college level.

Limitations of the Study

Certain limitations were established for the study in order to allow its completion. These limitations were stated as follows:

(1) The student population was limited to those

college students who were enrolled in the Introductory Bioconcepts Course (Biology 1004) at Southwestern Oklahoma State University (Weatherford, Oklahoma) during the fall semester of the 1976-77 academic year.

(2) The Botany and Biology concepts taught to the student population were limited to the materials taught in the Introductory Bioconcepts Course (Biology 1004) offered by Southwestern Oklahoma State University.

(3) The academic achievement information available for each student was limited to the pretest, posttest, and difference scores taken from the criterion-referenced testing instruments included in the audio-tutorial Bioconcepts program.

(4) Measures of students' attitudes were limited to the self-report student ratings taken from the attitude measurement instrument contained in the Appendices.

(5) The most significant limitation to the design of the study was the lack of a control group with which the students participating in the study could be compared.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The teaching of science is progressing rapidly because of the active interest in developing new approaches and new theories. Not only do instructors have at their disposal today an increasingly reliable knowledge about how people learn and how learning can be maximized, but they also have a lively exchange concerning the methods now being used.

Modern science education and curriculum improvement have been developing hand-in-hand since the Physical Science Curriculum Committee began the first major science curriculum reform in 1956. Although the first two projects following PSSC were by chemistry, the Chemical Bond approach and the Chemical Education Material Study, biologists instituted a substantial revision of their subject matter under the auspies of the Biological Science Curriculum Study. These were only the beginnings, however. Among the most promising of the developing science teaching techniques is the audio-tutorial method. The current literature illustrates constantly increasing interest in the method and results of this kind of teaching.

Definition of Audio-Tutorial

Audio-tutorial teaching is a pragmatic approach that emphasizes self pacing and flexibility for the student. It makes a great deal of use of multi-media materials in facilitating various areas of the approach.

History of Audio-Tutorial

The audio-tutorial system was begun in 1961 as an attempt to assist Purdue University students who had a poor background in introductory botany. Postlethwait and others have written general articles in this area (Postlethwait, 1969).

The rationale of the integrated experience approach to teaching at Purdue University is described as are the history of audio-tutorial courses at Purdue and its present organization. A sample week's unit of study is given, advantages of the system, and a discussion of the three sessions is presented (Postlethwait, 1970).

Evaluation

Evaluation of a curriculum may focus on three distinctive aspects of higher education. First, evaluation may concentrate on the environment, on the characteristics of the scene in which education takes place. It may also focus on the process, the quality and organization of the learning experiences provided. Finally, it may concentrate on the results, or on the progress and achievement of students.

The entering students constitute the input and the students with values added constitute the output (Dressel, 1971).

In a two course sequence on human anatomy, Muzio (1974) concluded that the audio-tutorial approach is an ideal method of fostering individualized learning, particularly for those students who have experienced academic difficulty. In a different study Marions (1971), who investigated the audio-tutorial teaching of plant physiology, found that audio-tutorial instruction was at least as effective as lecture laboratory teaching but had negative results on the students' retention span.

Hoffman (1971) indicated that students receiving audio-tutorial genetics instruction in an indirect mode were better able to use knowledge to solve genetics problems than those with more direct audio-tutorial instruction. Himes (1971), however, found different results. He studied the effectiveness of the audio-tutorial (A. T.) method of teaching general biology among freshman subjects during the 1970-71 academic year at Bloomsburg State College. Analyses were made of achievement scores on examinations taken by the experiemntal and control groups each semester. No evidence of enhanced benefits was illustrated as a result of the A. T. method during the semester. Students in the experimental group scored significantly higher during the second semester. Males in the experimental group attained higher scores than did females. Also, achievement differences between females of the two groups indicated a

significant difference in favor of the A. T. approach.

An evaluation and analysis of audio-tutorial instruction in a general education biology course was conducted by Weaver (1969). His study indicated that the audio-tutorial method of instruction was at least as effective as the traditional method of instruction. In cognitive areas, no significant differences in achievement existed between the two instructional methods. Achievement in the course content areas was not significantly different for the two instructional methods. Achievement variations among the groups were not conclusively related to sex and age.

Juby and Arnwine (1974) investigated a general biology course taught by the audio-tutorial method. The conventional biology grades were predicted for each of the eighteen students. The attained grades of the experimental group were higher than predictions.

Meleca (1968) used Multiple Linear Regression in a study using audio-tutorial materials as the vehicle for transmission of learning in a biology program. The results indicate that:

(1) SAT-M and CEEB biology are effective predictors of achievement in the audio-tutorial course.

(2) STEP- science and CEEB biology are effective predictors of achievement in the control.

(3) Students showing high aptitude in mathematics and biology achieve at a higher level in the audio-tutorial course than do students with comparable scores in the control group.

(4) Students with strong backgrounds in science and biology achieve at a higher level in the control group than do students with

> comparable backgrounds in the audio-tutorial group. (P. 6)

Elliott and Montgomery (1974) did a study of integration of audio-tutorial mini courses with the conventional biology lecture and laboratory. The rationale for as well as use and the effect of, and audio-tutorial mini-course in teaching basic biology are discussed. Statistical analyses of data from an evaluation questionnaire that was given the students at Hagerstown (Maryland) Junior College is presented.

Another study shows audio-tutorial activities in general chemistry based on accepted learning principles. The study involved the development, implementation and evaluation of laboratory audio-tutorial activities in a college chemistry course. The activities were designed in a self-instructional mode, written as linear programs and taped instructions (Sollimo 1973).

Moving beyond an already successful audio-tutorial program, Lower (1970) initiated a computer assisted tutorial program in solving chemistry problems. The advantages of computer assisted instructions over the audiotapes and advantages of both over the conventional instructional methods are discussed.

Sarenpa (1971) measured the effectiveness and efficiency, of audiotape recording using "time compressed speech" compared to those using normal recording rates in an audio-tutorial system. Results showed that the rate of

speech made no difference in the student's achievement. Little relationship was found between achievement and the personality characteristics of creativity and sociability as measured by the Remote Associations Test and the Thorndike Dimensions of Temperament Test. No advantage or disadvantage accrued from using time compressed recordings in an audio-tutorial system.

Using the pretest and posttest data collected from achievement and attitude instruments, Rowsey (1974) compared instruction using audio-tutorial in an animal biology course with a conventional method and found that students taught using audio-tutorial instruction demonstrated a significantly greater achievement gain but did not differ significantly in attitude toward course content; analysis of the opinion questionnaire revealed a favorable reaction by the experimental group toward the use of the audio-tutorial method of instruction.

Students studying a biology course by the audio-tutorial or conventional lecture laboratory methods differed in achievement on course examination, with the audio-tutorial group scoring significantly higher on the total test and three of the nine subtests (Sparks and Unbehaun 1971).

A "Direct" audio-tutorial method of teaching genetics was compared to "Indirect" audio-tutorial method of teaching genetics. The results showed that students receiving audio-tutorial genetics instruction in an indirect mode

were better able to apply their knowledge to solve genetics problems (Hoffman and Duger 1971). Linear Regression Analysis was used to determine the effectiveness of the Cooperative School and College Ability Test and the Fluency Test in predicting student performance on achievement tests used in an audio-tutorial elementary genetics program at Syracuse University. The cognitive tests were of most value in predicting achievement, accounting for 38 percent of the variance. The addition of the personality factors did not significantly increase the multiple correlation. The reactions of students to the audio-tutorial genetics course were also obtained; students generally enjoyed and approved of the method (Haakonsen 1969).

The relationships between two methods of presenting biological information (lecture-laboratory and audio-tutorial) and students attitudes toward biology and their terminal achievement were investigated by Vander (1972). Four instruments were administered as pretests and posttests to collect data; two student information questionnaires were employed, one at the beginning of the course and the second at the end. The following are some of the results obtained: (1) significant differences were not found between the mean scores on the pretests and posttests of attitudes for the students exposed to the audio-tutorial approach and (2) significant differences were not found between the mean scores obtained by the two groups

of students on the pretest for attitudes for two teaching methods.

The audio-tutorial method of teaching biology at the University of North Dakota was studied among 79 subjects during the fall term of the 1969-70 academic year to determine its effectiveness in comparison with the conventional method. Thirty-eight students were assigned randomly to the A. T. group and 41 to the control group. All subjects were given the "college entrance examination board advanced placement exam in biology". After completion of the course a posttest was administered to both groups. Statistical results showed the absence of significant difference in achievement between the two groups. College student's aptitude, secondary-school size, and science background did not contribute significantly to the prediction of college biology achievement under either the A. T. or conventional method of instruction (Grobe, 1970).

McDuffie (1973) examined relationships between personal characteristics and achievement in and attitudes toward an audio-tutorial biology program. The central question of the investigation was: Is there a different profile for (1) high and low achievers, (2) students with positive and negative attitudes toward the instructional method and (3) successful and unsuccessful students? An analysis of the results shows the following points: (1) Since the abilities, attitudes and personalities of the majority of the students were compatible with A. T.

instruction, the approach provided a desirable alternative to large group instruction in biology; (2) Personality factors were poor predictors of achievement and attitudes toward science and A. T. instruction; (3) The discriminant technique was better suited for predicting membership in high or low groups than was regression analysis.

A different kind of study directed at low achievers is that by Johnstone (1973) who presents an audio-tutorial unit that deals with the basic techniques involved in the use of the microscope. It can be used with high, medium or low level achieving students. A similar study illustrating the effectiveness of the audio-tutorial method of teaching general biology was studied among freshman subjects during the fall semester of the 1970-71 academic year at Bloomsburg State College. Analyses were made of achievement scores on examinations taken by the experimental and control groups each semester. Although no evidence of enhanced benefits was illustrated by the A. T. method during the fall semester, student achievement in the experimental group was significantly higher during the second semester.

The survey of literature shows that audio-tutorial methods proved favorable for most of the non-majors. Husband (1972) reveals a one-semester principles of biology course designed for non-majors was developed to utilize the audio-tutorial method. It was combined with the "mini-course" or concept pak approach. A total of 54 concept paks were developed along with 12 basic lessons. Students were

permitted to choose the specific concept paks that interested them most to complete the requirements of the course. The philosophy of the course was favorably received by 85 percent of the students, and the effectiveness of the concept pak as a means of teaching was demonstrated to be above average. A similar successful audio-tutorial program in biological science offered to non-science majors is the one at Western Michigan University (Hacket, 1973). One examination of the audio-tutorial and conventional methods of college level biology for non-science majors was investigated by Grobe (1973). He established the superiority of audio-tutorial instruction among 79 students by using the pretest-posttest control group design, and concluded the absence of significant difference in achievement analysis both between the control and experimental groups and varying aptitude subgroups.

Through his experiences in teaching a plant physiology course Marino (1971) concluded that the audio-tutorial instruction is at least as effective as lecture-laboratory teaching, and the negative retention span. Using an audio-tutorial approach in three sections of general biology courses, Shields (1973) did a study to determine the effects of behavioral objectives of achievement. Instruments used included the American College Testing Program scores (ACT) and the Cooperative Science Test (CST), biology - form B. Data collected were analyzed by a three-way analysis of variance designed by unequal subclasses. It concluded that

the results of the study do not support use of behavioral objectives as a procedure for enhancing achievement in an audio-tutorial class.

McDuffie (1973) reported a study of relationships between personal characteristics and achievement in and attitude toward an audio-tutorial biology program. His study discusses a sample of 119 volunteers who participated in a year long A. T. biology program. Data analysis was conducted in three phases: (1) The attitude toward the A. T. method questionnaire was given; (2) Step-wise regression analyses were performed; and (3) Comparisons between high and low achievement, attitude and success groups were conducted. It was concluded that abilities, attitudes, and personalities of the majority of students were compatible with A. T. instruction.

The effectiveness of an audio-tutorial mini-course for enrichment and remedial instruction in the biological sciences was conducted by Elliott (1972). He randomly selected 75 students in the experimental group and they attended regular lecture and laboratory periods in addition to completing 10 mini-courses. The 79 students in the control group also attended regular lecture and laboratory periods but completed library assignments on topics covered in the mini-courses. Pretests and posttests were administered to both groups after completing a topic. Data was based on the Otis Self-Administering Test of Mental Ability: The study found no significant difference to exist between

the posttest means of audio-tutorial group and the library research groups when the data was treated by analysis of covariance.

Another study that involved the use of an audio-tutorial system (plant taxonomy module) and its effect on cognitive learning was conducted by Hunt (1974). Hunt investigated and compared for two groups, one which received immediate reinforcement and feedback while the other group did not. Two groups of 24 students were randomly chosen from two lists of 150 students in the classes of the teachers. The first 24 students were the control group. Pre- and posttests containing 25 multiple choice responses were used to measure student performance. Data was analyzed using a multiple linear regression program. Hunt found: (1) the I. Q. of the students produced a significant difference in cognitive gains in both systems, and (2) the system employing immediate reinforcement and feedback produced significant and greater gains in cognitive learning than did the system without immediate reinforcement and feedback.

Sparks (1971), using an audio-tutorial format, participated in a study in which instructional time and quality was structured to accommodate for differences in students' abilities to attain their potential. Students in the experimental group who failed to achieve 80 percent on an evaluative checklist were required to participate in some corrective measure. The control group was not required to

achieve mastery on any of the subunits. At intervals during the course both groups were examined and the composite score from the biology achievement test was compared for the groups. Analysis of covariance was used to account for initial differences in the two groups. The achievement of the experimental group significantly exceeded that of the control group. Students in the experimental group exhibited a more positive reaction to the course.

The complication and evaluation of instructional objectives for introductory geology courses taught by the audio-tutorial approach at nine institutions in the United States was investigated by Nutter (1971). He found that schools that exhibited negative attitudes toward development of objectives or those that had been unsuccessful or less than enthusiastic about such course renovation were invariably those who had not formulated objectives to give their students.

Hill (1973) investigated the effects of the use of slide tape units as an instructional aid for the teaching of laboratory technique in a general college chemistry laboratory. The units were evaluated under three conditions of students' use: (1 and 2) required an optional viewing prior to the laboratory in a resource center; (3) viewing during and in the laboratory presentation. Test for evaluation of improvement in laboratory technique and creativity in chemistry were designed to assess student competency in these areas. Analysis of laboratory technique

pre- and posttest scores indicated a significant improvement at the .05 level. Analysis of creativity pre- and posttest scores of all sections indicated a significant improvement. The posttest scores showed no significant difference. The finding of the study most likely to have long range implications were thought to pertain to the students who used the slide tape units on an optional basis.

Summary

From the literature reviewed, it has been shown audio-tutorial instruction is at least as effective as lecture-laboratory teaching.

The audio-tutorial approach is a method of fostering individualized learning, particularly for those students who have experienced academic difficulty.

Students taught using the audio-tutorial instruction expressed greater achievement gain but did not differ significantly in attitude toward the course.

CHAPTER III

METHODS AND PROCEDURES

In the present study, two hundred ninety-eight (N=298) students enrolled at Southwestern Oklahoma State University at Weatherford, Oklahoma, acted as subject to evaluate any changes which may have occured in students' achievement and attitudes during the time they were enrolled in an introductory bioconcepts course which was taught by an audio-tutorial (A. T.) method. Students were required to attend lectures, science laboratories, and laboratory quiz sessions as part of the A. T. teaching method. A criterion-referenced test was given on a pretest-posttest basis to determine any changes in student achievement, while a Semantic Differential (SD) was used to determine students' attitudes. Data from these instruments were used to test the null hypotheses stated in Chapter I.

This Chapter contains a detailed explanation of the methods and procedures used in conducting the study. The methods and procedures were divided into three phases as follows: (1) Pre-Experimental Procedures, (2) Experimental Procedures, and (3) Data Analysis Procedures. Each of these areas is considered in the following sections of the dissertation.

Pre-Experimental Procedures

The pre-experimental procedures consisted of all those tasks which were completed before the data were collected from the participants. The most important of these procedures are explained in the following sections.

Choice of Research Design

The first pre-experimental procedure was to choose the proper research design for the conduct of the study. The words "research design" are intended to mean the plan, structure, and strategy of investigation conceived to obtain answers to research questions and to control external sources of variation. The Plan is the overall scheme or program of the evaluation problem; the Structure is the more specific structure or paradigm of the actual manipulation of the independent variables being studied; and the Strategy as used here is even more specific than the structure--it is the actual methods to be used in the gathering and analysis of the data (Kerlinger, 1973).

A research design serves two basic purpose: (1) it provides answers to research questions posed by the investigator; and (2) it controls external sources (independent variables) of variation. In other words, it is through the design of a study that research is made effective and interpretable. Kerlinger (1973) makes the following statement in regard to research and evaluation designs:

How does design accomplish this? Research

> design sets up the framework for 'adequate' tests of the relations among variables. The design tells us, in a sense, what observations [measurements] to make, how to make them, and how to analyze the quantitative representations [data] of the observations. Strictly speaking, design does not 'tell' us precisely what to do, but rather suggests the directions of observations should be made, and which variables [independent variables] are active variables and which are assigned. We can then act to manipulate [control] the active variables and to dichotomize or trichotomize or otherwise categorize the assigned variables. A design tells us what type of statistical analysis to use. Finally, an adequate [proper for the particular situation] design outlines possible conclusions to be drawn from the statistical analysis (pp. 196-97).

The research design chosen for the present experiment was a true experimental research design followed by the sampling of participants from finite populations. A paradigm of this research design is presented in Figure 1.

Population and Sample of Students

Enrollment figures indicated that there were two-hundred ninety-eight (N=298) students enrolled in the Biology 1004 course at Southwestern Oklahoma State University for the fall semester of the 1976-77 school year. Approximately eight percent (8.05%), twenty-four (N=24) students, were Science majors. The remaining ninety-two percent (92%), two-hundred seventy-four (N=274) students, were classified as non-science majors. Certain criteria were established for those included in the study. These criteria were as follows:

(1) Students must have scores on the pretest and posttest achievement test.

(2) Students must have scores on the pretest

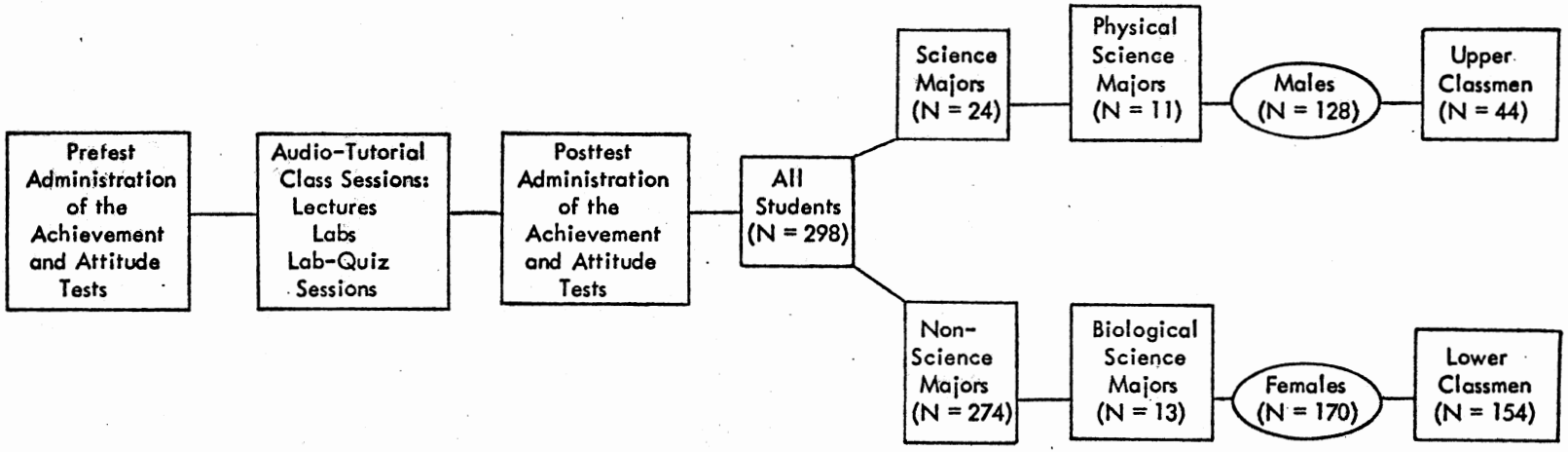

Figure 1. Research Design Used in the Study.

and posttest Semantic Differential.

(3) Students must attend at least eighty percent (80%) of the lectures, labs, and quiz sessions.

(4) Students must complete a teacher evaluation instrument.

(5) Students must have ACT scores.

The application of the screening criteria eliminated some of the participants. The final samples used in the comparisons were as follows:

Science Majors	N= 24	Non-Science Majors	N=274
Physical Science Majors	N= 11	Biological Science	N= 13
Females	N=170	Males	N=128
Upper Classmen	N= 44	Lower Classmen	N=154

Instrumentation

Two instruments were used in the study, a teacher-made test of achievement and a Semantic Differential (SD) for measuring students' attitudes. Each of these instruments is discussed in the following sections.

Development of an Achievement Test

It was necessary for the investigator to develop and standardize a criterion-referenced achievement test for measuring the students' achievement in the bioconcepts course. The achievement test contained 100 multiple-choice items which reflected the content of materials taught in the bioconcepts course. The researcher employed a test construction specialist to help in stating the achievement test items and in determining the quality of each item after a

pilot study has been conducted.

The content validity of the criterion-referenced achievement test was determined by the jury method (Good, 1971). This method required the Doctoral Committee and a jury of Science experts from Southwestern Oklahoma State University to examine the items to be included on the testing instrument. The jury of experts agreed that the questions being asked were indicative of the content being taught in the bioconcepts course.

Test-retest reliability of the achievement test was determined by comparing pilot study scores of students who were given the test at the beginning of the course and again two weeks later. Comparison of the pre- and posttest scores was made by using a Kuder-Richardson Formula #8 correlation technique (Kuder & Richardson, 1937). The pretest-posttest reliability of the instrument was established at 0.913.

Attitude Measure

Students' attitude changes were measured by administering a Semantic Differential (SD) on a pretest-posttest basis (Osgood, Suci, & Tannenbaum, 1965). The SD is constructed of words and concepts which are rated on a Likert-type response continuum.

The validity of the SD is reported by Buros as ranging from .64 to .81 (Buros, 1974). The test-retest reliability of the SD is reported by Osgood, Suci, and Tannenbaum (1972) as ranging from .82 to .93.

Experimental Procedures

The experimental procedures consisted of the actual teaching of the bioconcepts classes and the collection of data from the study participants. These procedures are explained in the following sections.

Teaching the Audio-Tutorial Classes

The introductory biology course at Southwestern Oklahoma State University, Biology 1004, was divided into three general areas; (1) lecture sessions, (2) laboratory sessions, and (3) laboratory quiz sessions.

Lecture Sessions

Lecture sessions were held three times per week by different Biology Professors during the semester. Sections were limited to approximately fifty (N=50) students each. Because of the large number of students enrolled in general biology courses at Southwestern Oklahoma State University, there were eight sections of students.

Lecture sessions were usually oriented toward the lecturing and discussing of a particular topic and the related objectives. An example of the laboratory and lecture sequence utilized during the spring semester of the 1975-76 school year is presented in Figure 2. The lecture sessions are also used for the evaluation of course objectives, general directions about course activities, and announcements concerning field trips scheduled for the general biology

Date	Unit of Study	Related Textbook Material
Jan. 13-16	------	Introduction: Ch. 1(1), Ch. 2(1)
Jan. 19-23	Microscope	Appendix A (618-629 (2) Ch. 3 (Omit Mitosis)(1)
Jan. 26-30	Ecosystem	Ch. 3 (Omit Mitosis), Ch. 4(2)
Feb. 2-6	Molecules of Life	Ch. 4 (2) Appendix A (629-631)
Feb. 9-13	Cellular Transport	Ch. 5 (2), Ch. 6 (1)
Feb. 16-20	Photosynthesis	Ch. 6 (2), Ch. 7 (1)
Feb. 23-27	Blood and Circulation	Ch. 8 (2), Ch. 9 (1)
Mar. 1-5	Animal Respiration	Ch. 10 (Omit Drugs) (2) Ch. 11 (1)
Mar. 8-12	Spring Break	-------
Mar. 15-19	Lab Examination(15-16) Irritability and Coordination	 Ch. 11 (1) Ch. 3 Mitosis (1)
Mar. 22-26	Mitosis and Meiosis	Ch. 12 (3)
Mar. 29-Apr. 2	Human Reproduction	Ch. 12 (1), Ch. 13 (2)
Apr. 5-9	Development	Ch. 14 (2), Ch. 15 (1)
Apr. 12-16	DNA and RNA	Ch. 15 (2), Ch. 17 (1)
Apr. 19-23	Genetics	Ch. 18 (1), Ch. 19 (1)
Apr. 26-27	Lab Exam (Final)	-------
Apr. 26-30	Drugs (Use and Misuse)	Ch. 20 (1), Ch. 21 (1), Ch. 22 (1)
May 3-4	(No Lab)	Ch. 23 (1), Ch. (24) (1)

Figure 2. Example of Laboratory and Lecture Sequence Utilized During the Spring Semester of the 1975-76 School Year

course.

Laboratory Sessions

The Laboratory Learning Center is equipped with 18 individual study carrells. Each carrell has 105 Sony tape recorders, an electrical source, microscope, slides, pictures, and other materials and equipment pertinent to the content of the bioconcepts course. In addition, the laboratory is equipped with three 4-foot X 8-foot tables which are used for displays and/or working stations for the students.

Laboratory sessions were conducted during fourteen weeks of the semester, each corresponding to a lecture session topic. Lab sessions related to each course unit were available to the student for a one-week period. During that time, each student was required to schedule and attend a lab session. The laboratory was open for student use from noon until 5:00 p.m. on Monday and from 8:00 a.m. until 5:00 p.m. Tuesday through Friday. Scheduling sheets were posted on the laboratory door, and each student was responsible for scheduling and attending a two-hour lab session during the week.

During the lab session, students listened to an audio-tape as part of the learning exercise. An audio-tape was prepared by one of the two professors in charge of the bioconcepts course. Tapes were designed to tutor each individual student through a series of learning events related to a particular unit of study. The audio-tape for

each unit included the basic theory, concepts, terminology, objectives, directions for conducting any experiments, instructions for demonstration materials, and instructions or directions for any other learning activities related to the particular unit of study.

A record of time spent in the audio-tutorial laboratory and a score indicating students' performance for each week's lab was kept on laboratory cards. Students also used these cards to check in and out of the laboratory center.

Quiz Sessions

The third aspect of the audio-tutorial teaching method was the quiz sessions. Students enrolled in a particular quiz section at the beginning of the course. Each quiz session of thirty students was scheduled to meet one hour each week. Professors in charge of the quiz sessions further divided the students into groups of fifteen each who meet for one-half hour. The purpose of the quiz session was to help students better understand any area of the previous week's laboratory session. These sessions were also used to evaluate each students' achievement in previous laboratory work. The student could earn up to 5 points per week in quiz sessions. Evaluation could be either oral or written and covered the instructional goals of the laboratory work.

The lab quiz session was an important ingredient of the audio-tutorial program in general biology because it enhanced discussion, encouraged interaction between students and

instructors and interaction among fellow students.

Data Collection Procedures

Students enrolled in a bioconcepts course (Biology 1004) were pretested by a criterion-referenced achievement test during the second week of the fall semester of the 1976-77 school year. The pretest was given at that time because it allowed late enrollees to take the achievement test, it also allowed for some students to withdraw from the course. The achievement posttest was administered during the third week of December. The final examination was administered during the last regular class meeting. This allowed a time lapse of fourteen weeks between testings.

The Semantic Differential (SD) was administered at the same time the achievement test was given. This served as the pretest of students' attitudes. The SD was administered a second time (posttest) during the third week of December, 1976. The experiment covered a total of fourteen weeks' time.

Additional data were collected on each student participant. These data represented variables which needed to be controlled in order to give the study external validity. Specifically, measures were taken on different laboratory instructors, ability levels, and attendance schedules.

Students completed the instructor evaluation shown in Appendix C. These ratings were used as covariables in the data analysis.

Data Analysis Procedures

The pretest-posttest achievement change scores and the pretest-posttest attitude change scores were used to test the hypotheses stated in Chapter I. The null hypotheses were tested by comparing the pretest-posttest change scores of attitude and achievement. These comparisons were made by utilizing a one-way analysis of covariance testing statistic (Winer, 1975). This statistical procedure allows the comparison of two or more sample means, while controlling the effects of other extraneous variables. In the present study, the extraneous variables controlled were; (1) differences among the instructors' performances (as determined by student ratings), (2) differences among the students' ability levels (as determined by their Science and Composite ACT scores), and (3) differences among the students' attendance schedules (as determined by their attendance in laboratory and laboratory quiz sessions).

CHAPTER IV

PRESENTATION AND ANALYSIS OF DATA

Two-hundred ninety-eight (N=298) college students enrolled in an introductory biology course at Southwestern Oklahoma State University during the 1976-77 academic year acted as subjects to determine the effects of an audio-tutorial (A. T.) method of teaching the course on the participants' academic achievement and their attitude toward the teaching method. Pretest-posttest achievement and attitude change scores were compared along several dimensions. Comparisons were made between (1) Science majors and non-science majors, (2) physical science majors and biological science majors, (3) males and females, and (4) upper classmen and lower classmen. Additional variables were statistically controlled in the study through the use of an analysis of covariance testing statistic. The covariables controlled were the professors' classroom performance, students' ACT scores, and class attendance patterns.

This chapter contains the results of all the data analysis. Each hypothesis is considered individually and in chronological order. A summary of each hypothesis and all the results are presented at the end of the chapter. Conclusions are presented in Chapter V.

Results of Testing Null Hypothesis Number One

The null proposition of the first hypothesis was tested as follows:

> Ho_1 There is no statistically significant difference between the students' achievement scores at the beginning of the bioconcepts course and their achievement scores at the end of the bioconcepts course.

The first null hypothesis was tested by comparing the students' pretest and posttest achievement scores taken from the standardized testing instruments. Means and standard deviations of the students' pretest, posttest, and change scores are presented in Table I. A one-way analysis of covariance was used to make the statistical analysis of the data. The results of the calculations are presented in Table II.

The results presented in Table II show that there was a highly significant difference between the students' pretest and posttest achievement scores ($F = 216.52$; $df=1/295$: $p < .0001$). These results allowed the researcher to reject the first null hypothesis.

An examination of the data presented in Table I shows that the student participants made more than fifteen percentage points gain ($\bar{X} = 15.084$) in their achievement scores during the time of the study.

TABLE I

MEANS AND STANDARD DEVIATIONS OF ALL STUDENTS' PRETEST, POSTTEST, AND CHANGE SCORES ON ATTITUDES AND ACHIEVEMENT

	ACHIEVEMENT		
	Pretest	Posttest	Change Scores
Mean	$\bar{X}$ = 45.935	$\bar{X}$ = 61.019	$\bar{X}$ = 15.084
Standard Deviation	S = 8.384	S = 8.722	S = 8.084

	ATTITUDES		
	Pretest	Posttest	Change Scores
Mean	$\bar{X}$ = 1129.62	$\bar{X}$ = 1159.31	$\bar{X}$ = 29.69
Standard Deviation	S = 187.63	S = 138.07	S = 154.98

TABLE II

ANALYSIS OF COVARIANCE OF STUDENTS' PRETEST-POSTTEST ACHIEVEMENT CHANGE SCORES WITH PROFESSORS, ACT SCORES, AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	4495	216.52	$p < .0001$
Within Groups	295	20.76		
TOTAL	296			

Results of Testing Null Hypothesis Number Two

The null proposition of the second hypothesis was tested as follows:

Ho_2 There is no statistically significant difference between the students' attitude scores at the beginning of the bioconcepts course and their attitude scores at the end of the bioconcepts course.

The second null hypothesis was tested by comparing the students' pretest and posttest attitude scores taken from the Semantic Differential Test. Means and standard deviations of the students' pretest, posttest, and change scores are presented in Table I. A one-way analysis of covariance was used to make the statistical analysis of the data. The results of the calculations are presented in Table III.

The results presented in Table III show that there was a significant difference between the students' pretest and posttest attitude scores ($F = 7.123$; $df=1/295$: $p < .001$). These results allowed the researcher to reject the second null hypothesis.

Visual examination of the descriptive statistics presented in Table I will show that there was a significant improvement in the students' attitudes during the course of the experiment.

TABLE III

ANALYSIS OF COVARIANCE OF STUDENTS' PRETEST-POSTTEST ATTITUDE CHANGE SCORES WITH PROFESSORS, ACT SCORES, AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Attitude Measure	1	16.17	7.123	$p < .001$
Error	295	2.27		
TOTAL	296			

Results of Testing Null Hypothesis Number Three

The null proposition of the third hypothesis was tested as follows:

Ho_3 There is no statistically significant difference between the science majors' pretest-posttest achievement change scores and the non-science majors' pretest-posttest achievement change scores.

The third null hypothesis was tested by comparing the two groups' pretest-posttest achievement change scores. The mathematical means and adjusted means of the two groups' change scores are presented in Table IV.

A one-way analysis of covariance was used to make the statistical comparison, with the professors' classroom performance, ACT scores, and class attendance as covariables. The results of the statistical analysis is presented in Table V.

The results presented in Table V show that there was a significant difference between the science majors' and non-science majors' achievement change scores ($F = 5.17$; $df=1/295$: $p < .05$). These results allowed the researcher to reject the third null hypothesis.

Examination of the two groups' achievement change scores in Table IV will show that the covariable adjustments made through the statistical analysis caused the science majors to have a much greater achievement change than the non-science majors.

CALCULATED AND ADJUSTED MEAN VALUES OF ACHIEVEMENT AND ATTITUDE CHANGE SCORES AS COMPUTED FOR THE VARIOUS GROUPS BEING COMPARED

Comparison Groups		ACHIEVEMENT CHANGE SCORES		ATTITUDE CHANGE SCORES	
		calculated mean values	adjusted* mean values	calculated mean values	adjusted* mean values
Science Majors	(N = 24)	$\bar{X}$ = 16.96	$\bar{X}^*$ = 22.64	$\bar{X}$ = 28.21	$\bar{X}^*$ = 6.27
Non-Science Majors	(N = 274)	$\bar{X}$ = 14.92	$\bar{X}^*$ = 12.65	$\bar{X}$ = 29.81	$\bar{X}^*$ = 37.44
Physical Science Majors	(N = 11)	$\bar{X}$ = 15.55	$\bar{X}^*$ = 14.43	$\bar{X}$ = 17.27	$\bar{X}^*$ = -7.21
Biological Science Majors	(N = 13)	$\bar{X}$ = 18.15	$\bar{X}^*$ = 16.17	$\bar{X}$ = 66.69	$\bar{X}^*$ = 31.05
Males	(N = 128)	$\bar{X}$ = 19.30	$\bar{X}^*$ = 30.22	$\bar{X}$ = 28.20	$\bar{X}^*$ = 14.45
Females	(N = 170)	$\bar{X}$ = 15.58	$\bar{X}^*$ = 10.06	$\bar{X}$ = 30.80	$\bar{X}^*$ = 41.65
Upper Classmen	(N = 44)	$\bar{X}$ = 16.82	$\bar{X}^*$ = 20.15	$\bar{X}$ = 59.73	$\bar{X}^*$ = 50.40
Lower Classmen	(N = 154)	$\bar{X}$ = 14.78	$\bar{X}^*$ = 11.83	$\bar{X}$ = 24.48	$\bar{X}^*$ = 29.33

*Mean values after adjustments had been made for differences between professors' performance, ACT scores, and class attendance schedules.

TABLE V

ANALYSIS OF COVARIANCE COMPARING THE SCIENCE MAJORS' AND NON-SCIENCE MAJORS' ACHIEVEMENT CHANGE SCORES WITH PROFESSORS, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	407.24	5.17	$p < .05$
Within Groups	295	78.77		
TOTAL	296			

Results of Testing Null Hypothesis Number Four

Ho_4 There is no statistically significant difference between the science majors' pretest-posttest attitude change scores and the non-science majors' pretest-posttest attitude change scores.

The fourth null hypothesis was tested by comparing the two groups' pretest-posttest attitude change scores. The calculated means and the adjusted mean values of the two groups' attitude change scores are presented in Table IV.

A one-way analysis of covariance was used to make the statistical comparison, with the professors' classroom performance, ACT scores, and class attendance as covariables. The results of the statistical analysis are presented in Table VI.

The results presented in Table VI show that there was a significant difference between the science majors' attitude change scores and the non-science majors' attitude change scores ($F = 6.23$; $df=1/295$: $p < .05$). These results allowed the researcher to reject the fourth null hypothesis.

A visual comparison of the two groups' attitude change scores in Table IV (adjusted mean values) will show that non-science majors had significantly greater attitude gains than that recorded for the science majors.

TABLE VI

ANALYSIS OF COVARIANCE COMPARING THE SCIENCE MAJORS' AND NON-SCIENCE MAJORS' ATTITUDE CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	677.88	6.23	$p < .05$
Within Groups	295	108.81		
TOTAL	296			

Results of Testing Null Hypothesis Number Five

Ho_5 There is no statistically significant difference between the physical science majors' pretest-posttest achievement change scores and the biological science majors' pretest-posttest achievement change scores.

The fifth null hypothesis was tested by comparing the two groups' pretest-posttest achievement change scores. The calculated mean values and the adjusted mean values computed for the two groups are presented in Table IV.

A one-way analysis of covariance was used to make the comparison, with the professors' performance, Science ACT scores, and class attendance as covariables. The results of the statistical analysis are presented in Table VII.

The results presented in Table VII show that there were no significant differences between the physical science majors' achievement change scores and the biological science majors' achievement change scores ($F = 0.347$; $df=1/21$: $p > .05$). These results would not allow the researcher to reject the fifth null hypothesis.

A comparison of the two groups' achievement change scores in Table IV shows that there was only a slight difference between the mean values before their adjustment by the covariables, and the difference became less as a result of the adjustment.

TABLE VII

ANALYSIS OF COVARIANCE COMPARING THE PHYSICAL SCIENCE MAJORS' AND BIOLOGICAL SCIENCE MAJORS' ACHIEVEMENT CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	2.364	0.347	$p > .05$
Within Groups	21	6.813		
TOTAL	22			

Results of Testing Null Hypothesis Number Six

Ho_6 There is no statistically significant difference between the physical science majors' pretest-posttest attitude change scores and the biological science majors' pretest-posttest attitude change scores.

The sixth null hypothesis was tested by comparing the two groups' pretest-posttest attitude change scores. The calculated mean values and the mean values after the covariable adjustments had been made are presented in Table IV.

A one-way analysis of covariance was used to make the comparison, with the professors' performance, Science ACT scores, and class attendance as covariables. The results of the statistical analysis are presented in Table VIII.

The results presented in Table VIII show that there was not a significant difference between the physical science majors' attitude change socres and the biological science majors' attitude change socres ($F = 1.913$; $df=1/21$: $p > .05$). These results would not allow the researcher to reject the sixth null hypothesis.

The two groups' calculated and adjusted mean values show that the covariable adjustments tended to eliminate any differences which may have existed between the two groups.

TABLE VIII

ANALYSIS OF COVARIANCE COMPARING THE PHYSICAL SCIENCE MAJORS' AND BIOLOGICAL SCIENCE MAJORS' ATTITUDE CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	8.67	1.913	$p > .05$
Within Groups	21	4.53		
TOTAL	22			

Results of Testing Null Hypothesis Number Seven

Ho_7 There is no statistically significant difference between the males' pretest-posttest achievement change scores and the females' pretest-posttest achievement change scores.

The seventh null hypothesis was tested by comparing the males' and females' pretest-posttest achievement change scores. The calculated mean values and the adjusted mean values are presented in Table IV.

A one-way analysis of covariance was used to make the comparison, with the professors' performance, Science ACT scores, and class attendance as covariables. The results of the statistical analysis are presented in Table IX.

The results presented in Table IX show that there was a significant difference between the males' and females' achievement change scores ($F = 7.19$; $df=1/295$: $p < .01$). These results allowed the researcher to reject the seventh null hypothesis.

A comparison of the adjusted means shown in Table IV indicate that the males made significantly higher achievement gains than the females.

Results of Testing Null Hypothesis Number Eight

Ho_8 There is no statistically significant difference between the males' pretest-posttest attitude change scores and the females' pretest-posttest attitude change scores.

TABLE IX

ANALYSIS OF COVARIANCE COMPARING THE MALES' AND FEMALES' ACHIEVEMENT CHANGE SCORES WITH PROFESSORS' PERFORMANCE ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	68.22	7.19	$p < .01$
Within Groups	295	9.49		
TOTAL	296			

The eighth null hypothesis was tested by comparing the males' and females' pretest-posttest attitude change scores. The calculated mean values and the adjusted mean values are presented in Table IV.

A one-way analysis of covariance was used to make the comparison, with the professors' performance, Science ACT scores, and class attendance as covariables. The results of the statistical analysis are presented in Table X.

The results presented in Table X show that there was a significant difference between the males' and females' attitude change scores ($F = 5.33$; $df=1/295$: $p < .05$). These results allowed the researcher to reject the eighth null hypothesis.

A comparison of the adjusted means shown in Table IV indicate that the females made significantly higher attitude gains than the males.

Results of Testing Null Hypothesis

Number Nine

The null proposition of the ninth hypothesis was tested as follows:

Ho_9 There is no statistically significant difference between the upper classmens' pretest-posttest achievement change scores and the lower classmens' pretest-posttest achievement change scores.

The ninth null hypothesis was tested by comparing the upperclassmens' and lower classmens' pretest-posttest

TABLE X

ANALYSIS OF COVARIANCE COMPARING THE MALES' AND FEMALES' ATTITUDE CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	204.51	5.33	$p < .05$
Within Groups	295	38.37		
TOTAL	296			

achievement change scores. The calculated mean values and the adjusted mean values are presented in Table IV.

A one-way analysis of covariance was used to make the comparison, with the professors' performance, Science ACT scores, and class attendance patterns as covariables. The results of the statistical analysis are presented in Table XI.

The results presented in Table XI show that there was a significant difference between the upperclassmens' and lower classmens' achievement change scores ($F = 6.13$; $df=1/295$: $p < .05$). These results allowed tha researcher to reject the ninth null hypothesis.

A visual comparison of the adjusted mean values for the two groups shown in Table IV indicates that the upper classmen made significantly greater achievement gains than the lower classmen.

Results of Testing Null Hypothesis

Number Ten

Ho_{10} There is no statistically significant difference between the upper classmens' pretest-posttest attitude change scores and the lower classmens' pretest-posttest attitude change scores.

The tenth null hypothesis was tested by comparing the upper classmens' and lower classmens' pretest-posttest attitude change scores. The claculated mean values and the adjusted mean values are presented in Table IV.

A one-way analysis of covariance was used to make

TABLE XI

ANALYSIS OF COVARIANCE COMPARING THE LOWER CLASSMENS' AND UPPER CLASSMENS' ACHIEVEMENT CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	37.44	6.13	$p < .05$
Within Groups	295	6.11		
TOTAL	296			

the comparison, with the professors' performance, Science ACT scores, and class attendance patterns as covariables. The results of the statistical analysis are presented in Table XII.

The results presented in Table XII show that there was a significant difference between the upper classmens' and lower classmens' attitude change scores ($F = 4.17$; $df=1/295$: $p < .05$). These results allowed the researcher to reject the tenth null hypothesis.

A visual comparison of the adjusted mean values for the two groups shown in Table IV indicates that the upper classmen made significantly greater attitude gains than the lower classmen.

Summary of Results

Ten hypotheses were tested for significance at the .05 level. The results of testing these hypotheses may be summarized as follows.

There was an overall significant improvement in the students' achievement and attitudes scores from pretest to posttest.

The science majors showed significantly more achievement gain than non-science majors, but the non-science majors showed a greater improvement in attitudes than the science majors.

A comparison of the physical science majors' and biological science majors' scores showed no significant

TABLE XII

ANALYSIS OF COVARIANCE COMPARING THE LOWER CLASSMENS' AND UPPER CLASSMENS' ATTITUDE CHANGE SCORES WITH PROFESSORS' PERFORMANCE, ACT SCORES AND CLASS ATTENDANCE AS COVARIABLES

Source of Variation	Degrees of Freedom	Adjusted Mean Squares	F-Value	Significance Level
Between Groups	1	314.12	4.17	$p < .05$
Within Groups	295	75.33		
TOTAL	296			

differences in either their achievement or attitude change scores.

A comparison between the two sexes showed that the males made significantly greater achievement gains than the females. On the other hand, females made significantly greater attitude gains than males.

The final comparison between the upper classmen and lower classmen showed that the upper classmen (Juniors and Seniors) made significantly greater gains in both achievement and attitude than the lower classmen.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER RESEARCH

The purpose of this study was to determine possible effects of an audio-tutorial method of teaching on the achievement and attitude of college students. More precisely, the purpose of the study was to determine the effects of an audio-tutorial method of teaching bioconcepts on the academic achievement and attitudes of students enrolled in a bioconcepts course at Southwestern Oklahoma State University during the fall semester of the 1976-77 academic year.

In the present study, two hundred ninety-eight (N = 298) students acted as subjects to evaluate any changes which may have occurred in students' achievement and attitudes during the time they were enrolled in an introductory bioconcepts course which was taught by an audio-tutorial (A. T.) method. Students were required to attend lectures, science laboratories, and laboratory quiz sessions as part of the A. T. teaching method. A criterion-referenced test was given on a pretest-posttest basis to determine any changes in student achievement while a Semantic Differential (SD) was used to determine

students' attitudes. Pretest-posttest achievement and attitude change scores were compared along several dimensions. Comparisons were made between (1) science majors and non-science majors, (2) physical science majors and biological science majors, (3) males and females, and (4) upper classmen and lower classmen. Additional variables were statistically controlled in the study through the use of an analysis of covariance testing statistic. The covariables controlled were the professors' classroom performance, students' ACT scores, and class attendance patterns.

Ten hypotheses were tested for significance at the .05 level. The results of testing these hypotheses may be summarized as follows.

There was an overall significant improvement in the students' achievement and attitudes from pretest to posttest.

The science majors showed significantly more achievement gain than non-science majors, but the non-science majors showed a greater improvement in attitudes than the science majors.

A comparison of the physical science majors' and biological science majors' scores showed no significant differences in either their achievement or attitude change scores.

A comparison between the two sexes showed that the males made significantly greater achievement gains than

the females. On the other hand, females made significantly greater attitude gains than males.

The final comparison between the upper classmen and lower classmen showed that the upper classmen (Juniors and Seniors) made significantly greater gains in both achievement and attitude than the lower classmen.

Conclusions

Several conclusions were drawn from the results of the study. The conclusions presented represent only those which can be supported by the statistical results presented in Chapter IV.

The conclusions are of two types those related to comparisons of achievement gains and those related to comparisons of attitude change. Conclusions about the hypothesis are not presented in chronological order.

Conclusions About Achievement Gain

Conclusion Number 1: Results of testing the first null hypothesis presented in Table II, led to the conclusion that student participants made significant gains in their knowledge of biological concepts as a result of their participation in the A. T. program.

Gains in student achievement were examined in much more detail in the study. Comparisons were made between the achievement gains of science and non-science majors,

physical science and biological science majors, males and females and upper classmen and lower classmen. Results of these comparisons are presented in the following sections.

Conclusion Number 2: Results of testing the third hypothesis, (Table V) led to the conclusion that science majors learned much more than non-science majors as a result of the A. T. program.

Conclusion Number 3: Results of testing the fifth null hypothesis, presented in Table VII, led to the conclusion that physical and biological science majors gained about the same amount in achievement as a result of their participation in the A. T. program.

Conclusion Number 4: Results of testing the seventh hypothesis, presented in Table IX, led to the conclusion that male participants made higher gains than the female participants.

Conclusion Number 5: Results of testing the ninth hypothesis, presented in Table XI, led to the conclusion that upper classmen made significantly greater achievement gains than the lower classmen.

Conclusions About Attitude Gain

Changes in student attitudes were examined in much more detail in the study.

Comparisons were made between the attitude of

non-science and science majors, physical science and biological majors, males and females, and upper classmen and lower classmen.

Conclusion Number 6: Results of testing the second hypothesis presented in Table III, led to the conclusion that the student participants had much better attitudes about the A. T. program after they had completed the course than before they began.

These results would not support the findings reported by Frye (1971). He reported a significant decline in student attitudes during a similar course and under similar conditions.

Conclusion Number 7: Results of testing hypothesis number four, presented in Table VI, led to the conclusion that non-science majors developed much more favorable attitudes toward the A. T. program than science majors.

Again, these results failed to support the findings reported by Frye (1971) resulting from a similar hypothesis. Frye reported no significant difference between the attitude changes of science and non-science majors.

Conclusion Number 8: Results of testing hypothesis number six, presented in Table VIII, led to the conclusion that there was not a significant difference between physical science majors' attitude and biological science majors' attitude.

Conclusion Number 9: Results of testing hypothesis number eight, presented in Table X, led to the conclusion

that female participants had a much better attitude about the A. T. program than the male participants.

Conclusion Number 10: Results of testing hypothesis number ten, presented in Table XII, led to the conclusion that upper classmen made greater attitude gains than the lower classmen.

The results fail to support the finding reported by Frye (1971). Frye reported no significant difference between the upper classmens' attitude scores and lower classmens' attitude scores.

Recommendations

The findings and conclusions of this study suggest several areas of research and innovation.

(1) Studies should be initiated to determine the long term attitude effects of audio-tutorial instruction.

(2) The economic aspects of audio-tutorial instruction should be investigated relative to cost per pupil related to attitudinal change and per achievement gain.

(3) Implications of the audio-tutorial method in conjunction with independent study progrmas in other disciplines should be explored.

(4) This study should be replicated over a longer period of time.

(5) Certain characteristics in students should be identified, and having done so, random samples should be drawn to set up a new study that would include an experimental group and a control group.

(6) The development of "Micro Courses" so that students could move more freely in the study of botany to fulfill more adequately the

individual needs and interests they have.

(7) Development of a standardized instrument for further attitudinal studies in the area of audio-tutorial instruction in zoology and other life sciences.

(8) A follow-up study of this same population to determine if a lapse of time after the audio-tutorial experience or if administration of this study had any influence on the student attitudes.

(9) Studies that would investigate the impact of maturation on the attitudes of students toward audio-tutorial science should be initiated.

(10) Studies should be initiated to determine if the audio-tutorial method of teaching, have any effects on achievement and attitudes of minority students.

(11) Students in audio-tutorial biology should be investigated in regards to their attainment of higher cognitive powers, the understanding of scientests and the scientific processes, and the transfer of learning as corollaries to achievement.

(12) Finally, if additional research is initiated as a consequence of this study the investigator will consider this study to have been successful and worthwhile to some degree.

(13) A follow-up study of this same population to determine if a lapse in time after the audio-tutorial experience or if the administration of this study had any influence on the student attitudes.

(14) Studies should be investigated with a larger population of science majors, biology majors and physical science majors to determine any significant difference in scores.

(15) Studies should be initiated to determine instructor's attitudes as they related to audio-tutorial instruction and student attitude.

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APPENDICES

APPENDIX A

CRITERION-REFERENCED ACHIEVEMENT TEST USED IN THE STUDY

1. Atoms with the same numbers of protons but differing numbers of neutrons are termed _____.

    a. Isotopes
    b. Ions
    c. Compounds
    d. Molecules

2. In a scientific investigation, to avoid needless duplication of effort, the investigator should _____.

    a. engage in a series of experiments
    b. review appropriate scientific leterature, especially journals which report research studies in his field
    c. make assumptions
    d. all of the above

3. Ionizing radiation damages living tissue primarily by _____.

    a. disrupting coded molecules like DNA and RNA
    b. splitting water molecules to produce damaging ions
    c. breaking bonds within organic molecules
    d. all of the above

4. The initial process of respiration in animals takes place in the _____ of the lungs.

    a. alveoli
    b. bronchial tubes
    c. diaphragm
    d. trachea

5. Which of the following is an example of asexual reproduction?

    a. "false pregnancy"
    b. identical twins
    c. parthenogenesis
    d. polyploid individual

6. The major function of the autonomic nervous system is to _____.

    a. transmit impulses from the brain to the central nervous system
    b. regulate and control the peripheral nervous system
    c. stimulate the endocrine glands into actions
    d. innervate the internal organs

7. When a chemical change occurs, the parts of atoms that are involved are _____.

    a. electrons
    b. protons
    c. neutrons
    d. nuclei

8. The energy of linking H atoms to CO_2 is brought about by means of _____.

   a. ATP molecules
   b. photolysis
   c. oxygen (oxidation)
   d. chlorophyll

9. Brightly colored and highly scented flowers represent an adaption for _____.

   a. nutrition for the developing embryos
   b. protection for the delicate seeds
   c. wind pollination
   d. insect pollination

10. 95 Percent of the material in cells, engage in a _____ type of bonding.

   a. covalent
   b. ionic
   c. transfer
   d. none of these

11. If the people in one particular society had a higher protein diet than those in another society the first society is probably _____.

   a. more affluent
   b. more nomadic
   c. less affluent
   d. more primitive

12. Ribosomes are somewhat analogous to zippers in their action because _____.

   a. they zip together two strands of RNA to produce DNA
   b. they match transfer RNAs with proper places on the mRNA
   c. they sometimes get "stuck" and thus cause abnormalities in cells
   d. they bring together identical amino acids (like teeth in a zipper)

13. If a population contains members with genotypes AA, Aa, and aa, then the gene pool of the population contains

   a. a and A
   b. Aa
   c. AA, Aa, and aa
   d. two phenotypes

14. Chromosome duplication as evidence by nucleic acid duplication occurs during the _____ of cell division.

   a. anaphase
   b. metaphase
   c. interphase
   d. prophase

15. Respiration in muscle tissue results in the formation of lactic acid, an "oxygen debt" that must be paid off eventually. This type of respiration is also termed _____.

    a. aerobic
    b. lactogenic
    c. anaerboic
    d. fermentation

16. The most useful application of the Hardy-Weinberg principle in human genetics is to ____.

    a. determine the frequency of an undesirable gene in population
    b. predict the sex ratio of future offspring in a population
    c. estimate the probability that a couple may have healthy, normal children
    d. indicate the genetic consequences of allowing two races to intermarry

17. The study of developmental biology is called _____.

    a. physiology
    b. ecology
    c. genetics
    d. embryology

18. There are virtually no green plants in the ocean below a depth of 100 meters because of____.

    a. water pressure
    b. insufficient carbon dioxide
    c. low temperature
    d. insufficient light

19. The most extensive practical application of the concept of nonsexual reproduction has probably been the area of _____.

    a. improving farm crops by crossing different varieties of plants
    b. grafting commercially useful plants on disease resistant rootstocks
    c. developing pure-bred lines of plants and animals
    d. transplanting organs and parts from one animal to another.

20. Which type of scientific test uses living organisms to show the presence or absence of hormones in a body fluid?

    a. sham operation
    b. bioassay
    c. gland removal
    d. hormone injection

21. Since chlorophyll is green, which part of the color spectrum must contain the energy used in photosynthesis ?

    a. the middle (green) portion
    b. the red end
    c. the energy is evenly distributed
    d. the opposite ends (red and violet)

22. All living organisms acquire and utilize the energy they need through chemical changes that take place mostly within their cells. These important processes constitute _____.

    a. digestion
    b. egestion
    c. synthesis
    d. metabolism

23. Suppose that you, as a plant breeder, developed a type of guava plant that bore seedless guavas. How could this new produce be sold in nurseries?

    a. as small packets of seed from the original plant
    b. as cuttings from the parent plant
    c. as dried, seedless guavas
    d. there is no feasible method for marketing this new plant

24. In closed circulatory systems, materials enter and leave the system through _____.

    a. sweat glands
    b. veins
    c. capillaries
    d. veins, arteries, and capillaries

25. The union of sodium and chlorine represents a type of bonding called _____.

    a. covalent
    b. sharing
    c. isotopic
    d. ionic

26. Each of the two "daughter" centromeres of a chromosome is attached to a spindle fiber. The centromeres begin to move apart, one to each centriole, and as they move they carry with them the daughter chromosomes. This paragraph refers to _____.

    a. prophase
    b. metaphase
    c. anaphase
    d. telophase

27. A major characteristic of life which brings about adjustment between plants, and animals to their surroundings is called _____.

    a. hereditary
    b. regulation
    c. adaptation and evolution
    d. metabolism

28. In meiosis the pairing of homologous chromosomes takes place during _____.

    a. metaphase II
    b. prophase I
    c. telophase I
    d. fertilization

29. Knowledge of the living world features extensive study of _____.

    a. chemical principles
    b. principles of physics
    c. biological principles
    d. none of these

30. The shape and form of the body is determined by _____.

    a. morphogenesis
    b. differentiation
    c. cleavage
    d. fertilization

31. The digestion of starch into simple carbohydrates in the small intestine is an example of ____.

    a. Intracellular digestion
    b. Dehydration
    c. Synthesis
    d. Extracellular digestion

32. As a general rule, ionizing radiation is most damaging to _____ cells.

    a. mature, stable
    b. actively dividing
    c. highly specialized
    d. food storage

33. The centromere is important in mitosis because it _____.

    a. forms the spindle
    b. duplicates the chromosome
    c. attaches the chromosome to a spindle fiber
    d. controls the formation of the nuclear membrane

34. Which of the following statements best describes the general chemical nature of vertebrate hormones?

    a. nearly all consist of amino acids in small groups and thus act very much like proteins
    b. are mostly fats called steroids in the form of very large molecules
    c. consist mostly of carbohydrates that are very sensitive to changes in temperature and pH
    d. They vary greatly in size and include amino acids, fats, and proteins

35. The longest stage in the human lifespan is concerned with _____.

    a. growth
    b. differentiation
    c. cleavage
    d. morphogenesis

36. A leaf showing a greatly thickened palisade layer, a thickened cutin, and stomata located in pits came from a plant that probably lived in which of the following places?

    a. mountain top
    b. desert
    c. tropical forest
    d. lake

37. When sodium ions rush into the axon and potassium ions flow out, an axon is said to be _____.

    a. disables
    b. synaptic
    c. sensitized
    d. depolarized

38. A major self-regulatory control system is the _____.

    a. skeletal system
    b. hormonal system
    c. muscular system
    d. reproductive system

39. Research indicates that the primary way genes exert their control over organismic activities is by means of _____.

    a. enzymes
    b. hormones
    c. ATP
    d. dominant alleles

40. Meiosis differs from mitosis in that in meiosis _____.

    a. the chromosomes do not show centromeres
    b. only the cells of the soma are involved
    c. two nuclear divisions are involved
    d. homologous chromosomes appear in the nucleus

41. An important point brought out by the Hardy-Weinberg law is that a stable genotypic ratio will be obtained_____.

    a. only when $p = q$
    b. in the first generation following random breeding
    c. at the end of two generations where each has been produced by random breeding
    d. eventually (8 to 10 generations) under conditions of random breeding

42. Muscle fatigue is thought to be the consequence of _____.

    a. lactic acid accumulation
    b. paying off the oxygen debt
    c. poisons in the blood stream
    d. lack of sufficient ATP molecules

43. Parthenogenesis is the condition in which the organism _____.

    a. has both male and female reproductive organs
    b. develops from an unfertilized egg
    c. is believed to arise spontaneously from inorganic matter
    d. develops normally from a fertilized egg

44. As the process of adaption continues over a long period of time, it becomes part of the gradual process of change known as _____.

    a. ecology
    b. genetics
    c. evolution
    d. cell division

45. Which of the following is the best description of a hormone?

    a. a chemical secreted in the body
    b. a chemical secreted by a gland
    c. a glandular secretion carried by the body fluids
    d. an internal secretion with many effects on the body

46. One of the most crucial aspects of the scientific method and the major basis for accepting or rejecting many hypothesis is _____.

    a. assumptions
    b. review of literature
    c. experimental design
    d. repeatability

47. Water is less suitable than air (land dwelling) as an environment for many forms of life because it _____.

    a. has more chemicals dissolved in it than does air
    b. has less available oxygen in it than does air
    c. does not support combustion as well as does air
    d. exhibits a smaller range of temperature changes than does air

48. A good example of ionic bonding is found in _____.

    a. neon gas
    b. water
    c. common table salt (Nacl)
    d. carbon monoxide

49. Which of the following represents the best stage in which to view the shape, size, and number of chromosomes?

    a. metaphase
    b. interphase
    c. telophase
    d. any stage when the cell is dividing

50. Which of the following would most likely change the genetic equilibrium of a population?

a. random reproduction
b. changing environment
c. enormous population size
d. presence of fewer dominant than recessive genes

51. A deficiency in Vitamin A could cause _____.

a. Pellagra
b. Scurvey
c. Diabetes
d. Vision problems

52. "No matter how strong the stimulus is, the nerve impulse has a fixed strength." This quotation is a brief explanation of the _____.

a. synapse theory
b. latency period
c. refactory time
d. all-or-none reaction

53. Describe a practical use of the bioassay technique.

a. detecting human diseases
b. determining the gravity of oil
c. measuring air pressure
d. early detection of pregnancy in humans

54. All living things_____. (choose the best answer)

a. posess an equal number of cells
b. have common characteristics
c. differ in characteristics

55. The cells least affected by radiation are _____cells.

a. bone marrow
b. reproductive
c. nerve
d. lymph node

56. Which of the following is not an isotope?

a. C^{12}
b. C^{1-}
c. C^{13}
d. C^{14}

57. Anthony van Leeuwenhoek stimulated the development of biology through which of the following discoveries?

    a. Cells
    b. Capillaries
    c. Microscope
    d. All of these

58. Auxins are to plants as _____ are to animals.

    a. enzymes
    b. hormones
    c. proteins
    d. nerve impulses

59. The concept of a population's "gene pool" refers to _____.

    a. the alleles of all the genes in the population
    b. all of the phenotypes in the population
    c. all of the genotypes in the population
    d. the frequencies of the dominant and recessive genes in a population

60. The evolutionary value of sexual reproduction as compared with asexual is _____.

    a. greater uniformity of offspring.
    b. greater variability among offspring
    c. the offspring are more like their parents
    d. larger numbers of offspring are produced

61. A disease associated with an abnormally high leucocyte count is _____.

    a. hardening of the arteries
    b. anemia
    c. diabetes
    d. lukemia

62. Which of these important factors bears on adaptation and evolution?

    a. flow of energy from individual producers (plants) to individual consumers (animals)
    b. biological growth that resultsfrom cell division
    c. all hereditary information is encoded in the basic hereditary material called DNA

63. If you placed 50 pure-bred black guinea pigs with 50 albino (recessive to black) guinea pigs and allowed the population to attain genetic equilibrium, what proportion of the population would you expect to be white?

    a. 75%
    b. 50%
    c. 25%
    d. less than 10%

64. Select from the four sequences the one that accounts for the mechanism of gene action according to recent evidence.

a. RNA → enzymes → Golgi → enzymes → traits
b. DNA → RNA → ribosomes → enzymes → traits
c. DNA → enzymes → mitochondria → traits
d. RNA → DNA → nucleus → traits

65. Atoms that share electrons, engage in a type of bonding called _____.

a. ionic
b. transfer
c. covalent
d. isomers

66. Lysosomes _____. (mark the best answer)

a. are small bodies found in some animals during infestions.
b. are involved in intracellular digestion
c. are found only in plants
d. participate in cell division

67. If an egg reaches the four-cell stage and the four cells come apart, what is the consequence?

a. quadruplets
b. mutation
c. meiosis
d. mitosis

68. Which of the following best illustrates the Hardy-Weinberg law?

a. the proportion of blue-eyed to brown-eyed people in the world has not changed greatly in the last ten generations
b. radiation greatly increases the rates of mutations in most organisms
c. dominant genes are generally present in higher numbers than are recessive genes
d. all of these illustrate the law equally well

69. Water is more suitable than air (land dwelling) as an environment for many forms of life because _____.

a. chemical reactions occur more readily in water than in an air atmosphere
b. food is more abundant than on land
c. more oxygen is potentially available than on land
d. temperature changes are less drastic than on land

70. An example of the detrimental effects of the antibody-antigen reaction is a(an) _____.

a. innoculation
b. immunity
c. reaction
d. allergy

71. Which of the following constitutes the "backbone" or noncoded portion of a DNA molecule?

    a. nitrogen bases
    b. sugar and phosphate units
    c. proteins
    d. nucleotides

72. Because of the way that cyanide affects organisms, it is generally regarded as a poison which affects the _____system.

    a. respiratory
    b. nervous
    c. blood vascular
    d. reproductive

73. Which of the following is <u>not</u> a role of water in cells?

    a. takes part in some reactions
    b. it serves as a basis for transport of material
    c. produces energy
    d. it serves as a medium for other reactions

74. Some snakes, called "pit vipers" (for example, the rattlesnake), have sensory pits on each side of the head between eyes and nostrils which are sensitive to _____.

    a. odors
    b. body heat
    c. sound
    d. vibrations

75. The best meaning of the term "digestive juices" is _____.

    a. enzymes that hydrolyze organic compounds
    b. acids that bread down food
    c. watery materials such as saliva and bile
    d. chemicals that dehydrolyze proteins and lipids

76. The first step in reproduction occurs at the _____.

    a. tissue level
    b. system level
    c. cellular level
    d. molecular level

77. A very low-pitched sound may be inaudible, but if repeated at frequent intervals it can be heard, thus illustrating the neural concept known as _____.

    a. summation
    b. latent period
    c. phonoreception
    d. refractory period

78. Water absorbed by roots is transported to stems mainly through the _____.

a. phloem
b. xylem
c. living cells of the bark
d. dead cells of the bark

79. Subatomic particles that carry a negative charge are called_____.

a. protons
b. neutrons
c. electrons
d. all of the above

80. Which of the following constitutes gastrulation?

a. infolding of one wall of the blastula
b. invagination of the gastrula wall
c. cell division resulting in a ball of cells
d. formation of a hollow mass of cells

81. If you place a potted plant on its side, the stem will gradually grow upwards. What environmental factor is affecting auxin here?

a. gravity
b. light
c. heat
d. oxygen

82. The energy required in the transmission of an impulse over a nerve is furnished by_____.

a. the brain
b. ATP
c. the autonomic nervous system
d. neural hormones

83. When Robert Hooke, in 1665, observed thin layers of cork with a lens and described his findings as "cells", he was actually seeing _____?

a. cytoplasm
b. cell walls
c. living cells
d. cell membranes

84. Atoms are said to be electrically neutral when the _____.

a. number of neutrons equals the number of protons
b. number of electrons equals the number of neutrons
c. number of electrons equals the number of protons
d. number of neutrons equals the number of electrons

85. Which of the following is the primary function of the xylem?

a. transport organic materials
b. transport water and minerals
c. collect heat
d. produce chemicals

86. All biochemical events within cells are controlled by _____.

a. RNA
b. the cytoplasm
c. the nucleus
d. DNA

87. Which of the following hormones does not belong with others?

a. androgens
b. FSH
c. estrogens
d. progesterone

88. The dark reaction portion of photosynthesis refers to which part of the reaction?

a. the formation of ATP
b. the photolysis of water
c. the reaction between H and CO_2
d. all of these

89. Chemical reactions in our bodies are speeded up most effectively by utilizing catalysts called_____.

a. fats
b. reactants
c. carbohydrates
d. enzymes

90. In the light phase of photosynthesis the radiant energy trapped by chlorophyll molecules is used to _____.

a. split carbon dioxide molecules
b. link carbon atoms
c. synthesize glucose molecules
d. split water molecules

91. If the lysosome of a cell is released improperly its contents may_____.

a. destroy the cell
b. cause the cell to divide
c. change the shape of the cell
d. produce chromosomes

92. Isotopes of an element have different weights because each isotope has a different number of _____.

a. electrons
b. protons
c. neutrons
d. shells

93. What function seems to be shared by auxins, gibberellins, and cytokinins?

a. promoting seed germination
b. accelerating cell division
c. inhibiting the growth of competing plants
d. regulating overall plant growth

DIRECTIONS: Select the proper term for the definitions given.

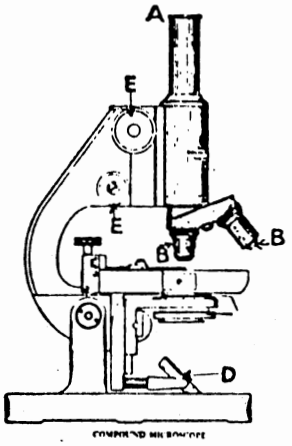
_____ 94. define (allele)
_____ 95. having 2 sets of chromosomes
_____ 96. offspring of homolygous parents
_____ 97. phenomenon caused by a change in the genes
_____ 98. the fertilized egg
_____ 99. all possible genes of a population
_____100. method for studying human genetics
_____101. observable characteristics
_____102. when contrasting genes occurs, as in Ww
_____103. separation of hereditary factors in meiosis

A. heterozygous
B. phenotype
C. hybrid
D. gene pool
E. allele
F. zygote
G. pedrigree chart
H. segregation
I. mutation
J. diploid

QUESTIONS 104-107 are related to Figure 1.

Questions 104-107 are related to Figure 1.

Figure 1



104. The proper name for the microscope part indicated by the letter "A" is the _____.

a. slide clips
b. ocular
c. adjusting knobs
d. eyepiece

105. What would be the effect if the microscope part indicated by the letter "D" were improperly positioned?

a. The slide would not be properly lighted
b. the slide could scratch the ocular
c. the slide might fall out
d. the slide would be out of focus

106. Which of the following is the function of the microscope parts marked "B"?

a. to hold the slide in place
b. to magnify the object being viewed
c. focus light on the slide
d. adjust the amount of light being reflected on the slide

107. The microscope parts marked by the letter "E" is used to _____ the microscope.

a. clean
b. transport
c. focus
d. magnify

APPENDIX B

ATTITUDE TEST (SEMANTIC DIFFERENTIAL) USED IN THE STUDY

SEMANTIC DIFFERENTIAL SCALE

Directions: The purpose of taking this measure is to assess the meanings of certain concepts to various people by having them judge the concepts against a series of descriptive scales. In doing this exercise, please make your judgment on the basis of what these concepts mean to you. On each page of this booklet you will find a different concept to be judged and beneath it a set of scales. You are to rate the concept on each of these scales in order of occurrence. Mark the scales in the following way:

If you feel that the concept at the top of the page is very closely related to one of the scale, you should place your check-mark as follows:

fair: X : : : : : : :unfair

fair: : : : or : : : X :unfair

If you feel that the concept is closely related to one or the other end of the scale (but not extremely), you should place your mark as follows:

good: : X : : : : : :bad

good: : : : or : : X : :bad

If the concept seems slightly more related to one side than the other (and is not really neutral), you should place your check-mark as follows:

weak: : : X : : : : :strong

weak: : : : or X : : : :strong

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the concept you are judging.

If you consider the concept to be neutral on the scale (both sides of the scale equally associated with the concept) or if the scale is completely irrelevant, (does not describe the concept at all), then you should place your check-mark in the middle space as follows:

honest: : : : X : : : :dishonest

IMPORTANT ! (1) Place your check-marks in the middle of the spaces, not on the boundaries:

(This) (Not This)

: : X : : : : X : : :

(2) Be sure to check every scale for every concept--do not omit any.

(3) Be sure you put ONE and ONLY ONE check-mark on each line of the scales.

Sometimes you may feel as though you've had the same item before on the sheets. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked a similar item that could have appeared earlier. Work at a fairly high rate of speed through this exercise since we are interested in your first impressions of the concepts. Do not worry or puzzle over individual items or their definitions, remember, its your first impressions, or the immediate "feelings" about the items, that we want. On the other hand, do not be careless and simply mark the middles of all the scales. This will only result in your having to take the test over again.

IF YOU HAVE READ ALL OF THE INSTRUCTIONS, YOU MAY OPEN YOUR BOOKLET AND BEGIN

COMPULSORY ATTENDANCE

fair	_____ : _____ : _____ : _____ : _____ : _____ : _____	unfair
good	_____ : _____ : _____ : _____ : _____ : _____ : _____	bad
weak	_____ : _____ : _____ : _____ : _____ : _____ : _____	strong
happy	_____ : _____ : _____ : _____ : _____ : _____ : _____	sad
unpleasant	_____ : _____ : _____ : _____ : _____ : _____ : _____	pleasant
honest	_____ : _____ : _____ : _____ : _____ : _____ : _____	dishonest
dull	_____ : _____ : _____ : _____ : _____ : _____ : _____	smart
worthless	_____ : _____ : _____ : _____ : _____ : _____ : _____	valuable
high	_____ : _____ : _____ : _____ : _____ : _____ : _____	low
clean	_____ : _____ : _____ : _____ : _____ : _____ : _____	dirty

INSTRUCTORS

fair	_____	unfair
good	_____	bad
weak	_____	strong
happy	_____	sad
unpleasant	_____	pleasant
honest	_____	dishonest
dull	_____	smart
worthless	_____	valuable
high	_____	low
clean	_____	dirty

GRADING SYSTEMS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

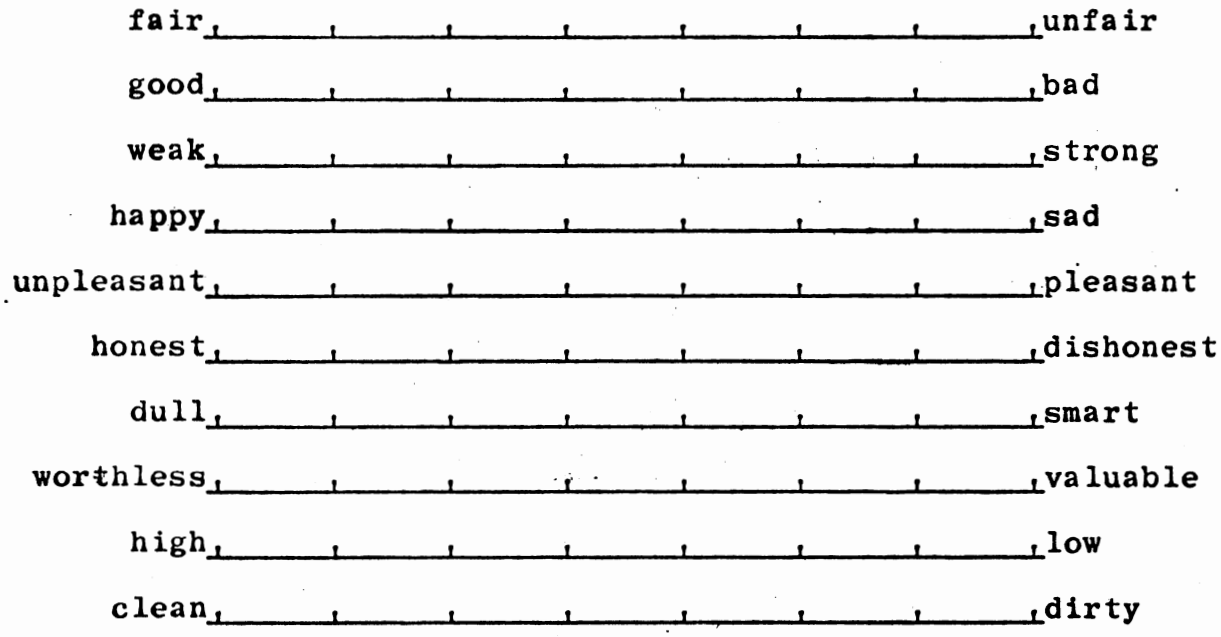
dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

AUDIO-TUTORIAL TEACHING



LABORATORY QUIZ SESSIONS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

COLLEGE-LEVEL SCIENCE COURSES

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

SCIENCE CLASS DISCUSSIONS

fair	_____	unfair
good	_____	bad
weak	_____	strong
happy	_____	sad
unpleasant	_____	pleasant
honest	_____	dishonest
dull	_____	smart
worthless	_____	valuable
high	_____	low
clean	_____	dirty

SCIENCE MAJORS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

TEACHING BY BEHAVIORAL OBJECTIVES

fair	:	:	:	:	:	:	:	unfair
good	:	:	:	:	:	:	:	bad
weak	:	:	:	:	:	:	:	strong
happy	:	:	:	:	:	:	:	sad
unpleasant	:	:	:	:	:	:	:	pleasant
honest	:	:	:	:	:	:	:	dishonest
dull	:	:	:	:	:	:	:	smart
worthless	:	:	:	:	:	:	:	valuable
high	:	:	:	:	:	:	:	low
clean	:	:	:	:	:	:	:	dirty

LECTURE SESSIONS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

LABORATORY ASSISTANTS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

AUDIOVISUAL TEACHING AIDS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

NON-SCIENCE MAJORS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

THE EXPERIMENTAL APPROACH TO SCIENCE

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

EXAMINATIONS

fair	_____	unfair
good	_____	bad
weak	_____	strong
happy	_____	sad
unpleasant	_____	pleasant
honest	_____	dishonest
dull	_____	smart
worthless	_____	valuable
high	_____	low
clean	_____	dirty

BIOLOGICAL SCIENCE INSTRUCTORS

fair	_____	unfair
good	_____	bad
weak	_____	strong
happy	_____	sad
unpleasant	_____	pleasant
honest	_____	dishonest
dull	_____	smart
worthless	_____	valuable
high	_____	low
clean	_____	dirty

CLASSROOM DEMONSTRATIONS

fair _____ unfair

good _____ bad

weak _____ strong

happy _____ sad

unpleasant _____ pleasant

honest _____ dishonest

dull _____ smart

worthless _____ valuable

high _____ low

clean _____ dirty

BIOLOGY 1004 (BIOLOGICAL SCIENCE)

fair	_____ _____ _____ _____ _____ _____ _____	unfair
good	_____ _____ _____ _____ _____ _____ _____	bad
weak	_____ _____ _____ _____ _____ _____ _____	strong
happy	_____ _____ _____ _____ _____ _____ _____	sad
unpleasant	_____ _____ _____ _____ _____ _____ _____	pleasant
honest	_____ _____ _____ _____ _____ _____ _____	dishonest
dull	_____ _____ _____ _____ _____ _____ _____	smart
worthless	_____ _____ _____ _____ _____ _____ _____	valuable
high	_____ _____ _____ _____ _____ _____ _____	low
clean	_____ _____ _____ _____ _____ _____ _____	dirty

BIOLOGY LABORATORY SESSIONS

fair	_____ : _____ : _____ : _____ : _____ : _____ : _____	unfair
good	_____ : _____ : _____ : _____ : _____ : _____ : _____	bad
weak	_____ : _____ : _____ : _____ : _____ : _____ : _____	strong
happy	_____ : _____ : _____ : _____ : _____ : _____ : _____	sad
unpleasant	_____ : _____ : _____ : _____ : _____ : _____ : _____	pleasant
honest	_____ : _____ : _____ : _____ : _____ : _____ : _____	dishonest
dull	_____ : _____ : _____ : _____ : _____ : _____ : _____	smart
worthless	_____ : _____ : _____ : _____ : _____ : _____ : _____	valuable
high	_____ : _____ : _____ : _____ : _____ : _____ : _____	low
clean	_____ : _____ : _____ : _____ : _____ : _____ : _____	dirty

MYSELF

fair	_____	unfair
good	_____	bad
weak	_____	strong
happy	_____	sad
unpleasant	_____	pleasant
honest	_____	dishonest
dull	_____	smart
worthless	_____	valuable
high	_____	low
clean	_____	dirty

APPENDIX C

INSTRUMENT USED TO EVALUATE INSTRUCTORS' CLASSROOM PERFORMANCE

EVALUATION FORM FOR CLASSROOM TEACHERS

DO NO SIGN YOUR NAME. Your cooperation is needed to obtain a rating of each of the teachers in this educational system. In this way we can help them to improve their teaching methods and improve education in general.

INSTRUCTOR: _____

Indicate your opinion by circling the appropriate number before each item.

5 - Excellent 3 - Average 1 - Poor
4 - Good 2 - Below Average

5 4 3 2 1	1. The teacher has a well-rounded knowledge of the subject matter in the area.
5 4 3 2 1	2. The teacher is willing to admit error or a lack of knowledge about certain areas.
5 4 3 2 1	3. The teacher shows a lot of enthusiasm for the topic.
5 4 3 2 1	4. The teacher holds the attention and interest of the class at all times.
5 4 3 2 1	5. The teacher stimulates a lot of interaction with the students.
5 4 3 2 1	6. The teacher has a pleasant voice and is easily heard.
5 4 3 2 1	7. The teacher has an understanding attitude toward the students' problems.
5 4 3 2 1	8. The teacher encourages the students to express their own ideas.
5 4 3 2 1	9. The teacher is able to maintain order at all times.
5 4 3 2 1	10. The teacher gives clear examples and illustrations.
5 4 3 2 1	11. The teacher was able to make the students think.
5 4 3 2 1	12. The teacher didn't try to put the students down.
5 4 3 2 1	13. The teacher let you know what was expected of you.
5 4 3 2 1	14. The teacher was fair with all students but didn't seem to play favorites.
5 4 3 2 1	15. The teacher used audio-visuals often.
5 4 3 2 1	16. The teacher really made you think.

VITA

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Doctor of Education

Thesis: EVALUATION OF AN AUDIO-TUTORIAL METHOD OF TEACHING BIOCONCEPTS AT SOUTHWESTERN OKLAHOMA STATE UNIVERSITY

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